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Chemical properties and C storage potential of natural scrubland charcoal

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Incomplete combustion during vegetation fire can lead to the conversion of plant and soil organic matter (OM) into charcoal. The thermally altered OM is considered to contribute to the stable pool of soil C. Most of the data on thermal alteration of plant material were obtained in the laboratory, whereas fire consequences on ecosystem C storage calls for data collected in natural-fire conditions. The objective of this study was to relate the quality of visually-identified litter charcoal and the temperature recorded during a scrubland prescribed fire.

Litter was sampled before and after the fire along a transect in the 30 ha experimental site. Litter-size fractions were analyzed for chemical composition and properties by elementary and isotopic analysis, solid-state ^{13}C nuclear magnetic resonance spectroscopy, differential scanning calorimetry and quantification of oxidation-resistant pyrogenic C. The maximum temperature reached within the litter layer during fire was assessed with thermo-sensitive paints.

Our results showed that fire had little effect on bulk litter composition because the fire event induced a large litter fall of both charred and non-charred material, resulting in the impossibility to distinguish new-litter-input and charring processes. As a consequence, the visual identification and separation of burned and unburned material constituted an essential preliminary step for chemical characterization of thermally

altered organic matter. Fire temperatures ranged from 370 to 650°C. Charring significantly increased the litter C concentration by 115 to 142 mg g⁻¹ under the effects of dehydration and aromatization processes occurring above 370°C. A significant correlation appeared between the production of aromatic structures, the decrease of O-alkyl C contribution and the temperature. The relationship between the maximum temperatures reached during the natural fire and the chemical transformation of the litter organic matter appeared highly consistent with previous results obtained under controlled conditions. Heating also led to a significant decrease of the $\delta^{13}\text{C}$ that we interpret as a higher thermal sensitivity of ¹³C-rich molecules.

The elemental composition, NMR and thermal spectra are consistent with the low oxidation-resistant C concentration of this natural charcoal (16±5 % OC), reflecting a low condensation degree compared to graphitic-like model. These findings suggest that leaf-derived charcoal produced during natural vegetation fire may have a lower C storage potential than previously assumed.